**NERRS Science Collaborative Progress Report for the Period 02/28/2012 through 8/31/2012**

**Project Title:** Nitrogen Sources and Transport Pathways: Science and Management Collaboration to Reduce Nitrogen Loads in the Great Bay Estuarine Ecosystem

**Principal Investigator(s):** William H. McDowell (UNH, NH WRRC; Lead PI), John P. Bucci (UNH, NH WRRC), Erik Hobbie (UNH, Stable Isotope Laboratory), Charlie French (UNH Cooperative Extension), Michelle Daley (UNH, NH WRRC), Jody Potter (UNH, NH WRRC), Steve Miller (Great Bay NERR) and Phil Trowbridge (NH DES, PREP).

**Project start date: 09/01/2010**

**Report compiled by:** William H. McDowell, Michelle Daley, Charlie French and Steve Miller

**Contributing team members and their role in the project:** William H. McDowell (oversees all project activities), Michelle Daley (manages field work, works collaboratively with stakeholders and is responsible for GIS analysis and data synthesis), Charlie French (science Integration Leader), Steve Miller (assists with science integration), Jody Potter (manages laboratory analyses and is responsible for caffeine and optical brightener analysis) and. John P. Bucci (responsible for mitochondrial (mt) DNA analysis) and Erik Hobbie (responsible for isotopic analysis of sediment)

**Nitrogen Sources Collaborative-Science Advisory Board members:** Members represent a diverse group of stakeholders from the Great Bay watershed including municipal planners and decision-makers, representatives of non-profit organizations, and local and regional businesses. All volunteer their time to meet, engage with the research team, learn about the research being conducted, and discuss how the research results can make a positive impact in the Great Bay watershed.

A. Progress overview: State the overall goal of your project, and briefly summarize in one or two paragraphs, what you planned to accomplish during this period and your progress on tasks for this reporting period. This overview will be made public for all reports, including confidential submissions.

**Overall goal of the project:** To detect non-point nitrogen sources and transport pathways in the Great Bay watershed while engaging decision makers in the science to ensure results are useful and will ultimately help reduce nitrogen loads in the Great Bay estuarine system.

**Revised Project Objectives** (based on stakeholder feedback described previously):

1. Integrate scientific investigations with stakeholders to ensure results are useful and accessible to environmental managers and other stakeholders
2. Identify, model and map N concentrations in surface waters throughout the Great Bay Watershed to identify "hot spots"
3. Identify non-point sources of N that reach surface waters and the delivery pathway (e.g. groundwater vs. stormwater) using tracers
4. Quantify N attenuation in large river reaches by modeling N inputs and outputs and inferring N attenuation

During this reporting period our goal was to work on objectives 1, 2 and 3. We planned to host approximately quarterly meetings with our Nitrogen Sources Collaborative Advisory Board (NSCAB), distribute our Great Bay nitrogen sources newsletter: "Nitrogen Sources Newsbytes" in conjunction with NSCAB meetings, collect and analyze samples from extensive and intensive sites, assess watershed characteristics for all stream sites in collaboration with the New Hampshire Geological Survey (NHGS) using GIS layers developed by and/or used by NH DES in their Great Bay Nitrogen Pollution Sources Study (GBNPSS) and begin to develop and apply landscape models that predict nitrogen concentrations based on watershed characteristics . Instead of holding two 2 hour quarterly NSCAB meetings, we decided to engage NSCAB members on a 4 hour laboratory tour and field trip in July. A "Nitrogen Sources Newsbytes" newsletter was released in August which described the NSCAB lab tour and field trip, relevant resources for the project and solicited feedback on what information final map products should include. Approximately 250 extensive sampling sites were sampled 3 times during this reporting period for a total of approximately 750 samples collected to assess the range of nitrogen concentrations in streams throughout the watershed and to look for nitrogen "hot spots". Additional samples for nitrogen concentrations were collected from the intensive sites and in August samples were collected for tracer testing and application during summer baseflow conditions. NH DES finalized and released the census 2010 population density on septic and sewer in July and we have subsequently met with the New Hampshire Geological Survey (NHGS) to formalize a plan to characterize the population density on septic and sewer, land use, impervious surfaces and estimate the directly connected impervious area (DCIA). Models that predict nitrogen concentrations based on watershed characteristics could not be developed or applied to our extensive sampling sites during this reporting period because additional time is needed to fully characterize our sites watersheds using GIS after the release of the NHDES population density on septic or sewer data.

B. Working with Intended Users:

- Describe the progress on tasks related to the integration of intended users into the project for this reporting period.

Our main mechanism for integrating intended users into the research project is the Nitrogen Sources Collaborative Advisory Board (NSCAB) and distribution of the Nitrogen Newsbytes Newsletter. NSCAB members include civic leaders, community decision-makers, business owners, and others who have a stake in the Great Bay nitrogen issues and want to help ensure that good science leads to sound community decision-making. Typically quarterly NSCAB meetings are held to discuss project objectives, progress towards objectives, next steps and final products.

**July 2012 NSCAB lab tour and field trip:** In lieu of two 2 hour quarterly NSCAB meetings, we decided to engage NSCAB members on a 4 hour laboratory tour and field trip on July 26, 2012. The Science Team took members of the NSCAB into the UNH Water Quality Analysis Laboratory (WQAL) and the field to experience the science in action. Members of the NSCAB visited the laboratory where most of the sample analysis for this project takes place and learned how nitrogen concentrations and different tracers are analyzed. Dr. McDowell (lead PI) and Jody Potter (WQAL manager) lead the laboratory tour and with the assistance of other research team members walked the NSCAB through the facilities, explaining the water quality testing procedures and equipment used, and talked about all the quality control measures used by the lab. After the lab visit, the NSCAB went on a field trip lead by Michelle Daley, Steve Miller and Charlie French. The NSCAB visited three project field sites located in and around Durham in the Oyster and Lamprey watersheds representing urban, agricultural and suburban land uses. In addition to collecting water samples using the project protocols, NSCAB members used project field sampling equipment and recorded field data. Members were also shown a recently installed bioretention basin optimized for phosphorous and nitrogen removal in a Durham parking lot near one of the sampling sites. The lab tour and field trip were highlighted by excellent questions and meaningful discussions about the work and gave NSCAB members a solid hands-on experience in the lab and field.

Click on the following link to see the highlights of the trip captured on YouTube:
http://www.youtube.com/watch?v=QE8qWkPplfY

**Nitrogen Newsbytes Newsletter:** The integration team worked with the scientists, as well as members of the NSCAB to develop a newsletter that provides an overview of the project, provides updates on data collection and results, discusses management implications, and enables stakeholders to share input. Content has been contributed by members of the NSCAB and other community partners. A third issue of the newsletter was distributed in August 2012. The subscribers list has grown from 13 last Fall to over 110 subscribers representing diverse interests (e.g. sewer districts, conservation and watershed organizations, taxpayers, national Senator staffers (Shaheen), etc.

**Needs Survey:** In the August 2012 Nitrogen Newsbytes newsletter, a web-based survey was included to solicit input on what sort of data community stakeholders and watershed-focused organizations would like to see depicted in a Google Map product. Such data may include nitrogen concentrations at each site, nitrogen hot spots, and watershed characteristics (e.g. land use, population density, impervious surfaces). A draft map which was developed with input from NSCAB members, can be seen at: http://snipurl.com/greatbay-nitrogen

**Lamprey Rivers Advisory Committee (LRAC) meeting presentation:** The local advisory committee for the Lamprey River and its major tributaries invited Michelle Daley to present on March 22, 2012 to the newly expanded committee. In 2011, the LRAC grew from a 4 to 14 town committee and now includes 28 total representatives from all towns that share the Lamprey watershed boundary. The committee, and especially the new members, wanted to better understand the nitrogen issues in Great Bay and the Lamprey watershed.

**NH Water and Watershed Conference March 2012**: The New Hampshire Water and Watershed Conference is designed to meet the information and networking needs of scientists; educators; consultants; students; lake, river, and watershed groups; environmental organizations; volunteer monitors; municipal board and staff members; elected officials; local and regional planners; and policy makers. Almost 200 people attended this conference on March 23, 2012 and Michelle Daley presented an update on this project entitled: "Non-Point Nitrogen Sources and Transport Pathways in the Great Bay Watershed".

**Living on Great Bay evening lecture series at the Exeter Universalists Unitarian Church:** On May 16, 2012, Steve Miller and Michelle Daley were invited to present on "Great Bay Challenges: What is the problem and what are the sources of its pollution?" Steve Miller presented on the environmental issues of Great Bay introducing the nitrogen issue and Michelle Daley explained the nitrogen issue in detail as well as introduced participants to this project and its goals and outcomes. Audience members were introduced to the Nitrogen Newbytes Newsletter and invited to subscribe. Twenty eight people were in attendance, many of them new faces to the nitrogen discussion.

**The New England Interstate Water Pollution Control Commission (NEIWPCC) Annual Nonpoint Source Pollution Conference:** This conference serves as a premier forum in New England for sharing information and improving communication on non-point source (NPS) pollution issues and projects. The conference brings together all those in New England and New York State involved in NPS pollution management, including participants from state, federal, and municipal governments, private sector, academia, and watershed organizations. The 2012 conference was held in Portsmouth NH on May 15 & 16 and Michelle Daley was invited to speak to participants about "Nitrogen Drivers in Great Bay Watersheds" during the Great Bay boat tour/field trip.

- What did you learn? Have there been any unanticipated challenges or opportunities?

  Key lessons learned are:

  - Despite disagreement about the magnitude of the nitrogen problem in Great Bay, and the drivers of the problem, NSCAB members and community stakeholders want to see the science conveyed in a form that is not only understandable to the lay person, but also usable by decision-makers.
  - The NSCAB is fully engaged and deeply interested in this and other nitrogen studies. They have demonstrated through their questions that they understand the issue and that they want to be sure the work being done is trusted and used.
  - The electronic Nitrogen Newsbytes Newsletter is an excellent vehicle for getting out information as well as providing a feedback loop to get input from stakeholders on the work.
  - The is very strong interest in this Nitrogen Sources and Transport study on the part of the public, the SWA, seacoast organizations, and other stakeholders who are not on the NSCAB.
  - Excellent input has been received about maps and other potential final products of the NSC Nitrogen Sources study.
  - The NSCAB laboratory and field trip during this reporting period reinforced the value of exposing end users to the actual process and procedures of the science as well as having direct access to the researchers to ask questions. It was clear during this lab tour and field trip that the NSCAB was gaining a new perspective on the science, and having direct access to the researchers allowed them to get an answer not only verbally but to "see" the answer in practice. This was/is invaluable in creating trust in the science.

- Who has been involved?

The NSCAB, Sewer District representatives, state environmental services staff, Lamprey River Watershed Association, Trout Unlimited, Southeast Watershed Association, Newmarket Town Council and Conservation Commission, Marine Docents, US Senator Shaheen's office (via newsletter), state representatives (Spang, Borden, etc.).

- Has interaction with intended users brought about any changes to your methods for integration of intended users, the intended users involved, or your project objectives?

In earlier stages of the project, interaction with intended users greatly changed our project objectives. During this reporting period, interaction with intended users continues to shape the products that will be developed. The newsletter is a new communications tool that has been very useful for connecting with stakeholders on this project.

- How do you anticipate working with intended users in the next six months?

We will continue our quarterly NSCAB meetings and quarterly release of the Nitrogen Newsbytes Newsletter to solicit feedback on the project and products produced. When there

are opportunities to present to interested stakeholders, this nitrogen sources and transport project team will welcome the opportunity. One new opportunity to engage with stakeholders outside of the NSCAB will be at the State of Our Estuaries Conference in December. We have contacted PREP to explore the possibility of incorporating an update and feedback session for this project into the conference agenda. We will also present an update on this project at the Annual Lamprey River Science Symposium and offer to meet with attendees in a more informal setting over lunch to discuss the project in more detail. A timeline for the next six months (Year 3, Q1 and Q2) as well as the remainder of the project can be found in Table 1.

Table 1. Revised objectives and activity timeline. Tasks that were completed in previous reported periods are marked as "completed".

| List Project Objectives, Products, Activities | Year 2 | | Year 3 | | | |
|---|---|---|---|---|---|---|
| | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| ***Objective 1:Integration of Science with End Users*** | | | | | | |
| Engage stakeholders in framing the research questions | Completed | | | | | |
| Utilize NSCAB to guide the science objectives and desired products | | x | x | x | x | x |
| Great Bay nitrogen sources newsletter: "Nitrogen Sources Newsbytes" | | x | x | x | x | x |
| Adapt science in the field to address stakeholder input/needs | x | x | x | | | |
| Stakeholder analyses and review of findings | | x | x | x | x | |
| Develop products that are useful for decision-makers | | | | x | x | x |
| Explore publication products with stakeholders | | | | | | x |
| ***Objective 2: Identify, model and map N concentrations to identify "hot spots" – Extensive sites*** | | | | | | |
| ***Site Designation*** | | | | | | |
| Assess catchment characteristics as delineated and described by NH Geological Survey (NHGS) | Completed | | | | | |
| Select ~250 study sites and generate maps necessary for initial sample collection | Completed | | | | | |
| Revise study site locations after site visit, sample collection and analyses | Completed | | | | | |
| Revise maps necessary for field collection | Completed | | | | | |
| ***Field sampling and Laboratory analyses*** | | | | | | |
| Collect stream samples from extensive sites | x | x | | | | |
| Process and analyze stream samples from extensive sites | x | x | x | x | | |
| Compile data for analyses of N concentrations. | x | x | x | x | | |
| ***Create models and maps of N concentrations and "hot spots"*** | | | | | | |
| Delineate watersheds for final extensive sites and characterize attributes (land use, population density, impervious cover etc.) | | | x | x | | |
| Apply Lamprey DIN vs. population density model to extensive sites | | | x | x | | |
| Develop Great Bay landscape model that predict N concentrations | | | x | x | x | |
| Identify "hot spots" where N concentrations are higher than expected | | x | x | x | | |
| Map N concentrations and "hot spots" | | x | x | x | | |
| Apply N model to NHGS catchments (~3500) and identify those at risk for high N | | | | x | x | |
| Share available data with NHDES for accuracy assessment of nitrogen pollution source study | | | x | x | x | |

| List Project Objectives, Products, Activities | Year 2 | | Year 3 | | | |
|---|---|---|---|---|---|---|
| | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| ***Objective 3: Identify N sources in surface waters and the delivery pathway – Intensive sites*** | | | | | | |
| Select ~12 study sites that represent a single N source to test tracers | Completed | | | | | |
| Collect source water samples from tracer testing sites and analyze N fractions | x | x | x | x | | |
| Isotopic analysis ($^{15}N$ , $^{18}O$ ) of nitrate source water | | x | x | x | | |
| Caffeine, optical brightener and mitochondrial DNA analysis of source water | x | x | x | x | | |
| Sediment collection and $^{15}N$ analysis of tracer testing sites | x | | | | | |
| Select ~8 "hot spots" study sites to apply tracers | | x | x | | | |
| Collect water and sediment samples from tracer application sites during baseflow and storms | | x | x | x | | |
| Analyses of tracers and N fractions at tracer application sites | | x | x | x | x | |
| Data analyses | x | x | x | x | x | |
| Prepare statistical (ongoing and final) analyses | x | x | x | x | x | |
| ***Objective 4: Estimate N attenuation in large river reaches*** | | | | | | |
| Model N inputs and outputs and infer N attenuation | | | | | x | |
| ***Prepare Publications*** | | | | x | x | x |

C. Progress on project objectives for this reporting period:

- Describe progress on tasks related to project objectives for this reporting period.

Progress on **objective 1**: Integrate scientific investigations with stakeholders to ensure results are useful and accessible to environmental managers and other stakeholders

See section B

Progress on **objective 2**: Identify, model and map N concentrations in surface waters throughout the Great Bay Watershed to identify "hot spots".

Most of the progress on this task centered on collecting 3 rounds of samples from the ~250 extensive sampling sites resulting in ~750 samples collected from streams throughout the watershed. At this point we have 5 rounds of extensive site sampling (October 2010, May 2011, May/June 2012, June/July 2012 and July/August 2012) and these samples will be used to assess nitrogen concentrations at sites draining watersheds with various landscape characteristics (i.e. land use, population density and impervious cover) and to look for nitrogen "hot spots". Samples collected in 2012 are currently being analyzed for nitrogen concentrations. We have assessed GPS coordinates and field data from the May/June 2012 sampling and are in the process of assessing field data from the final two summer sampling rounds.

We had planned to characterize the watershed attributes at our extensive sites during this reporting period, but this task will begin next reporting period now that some of the data layers that NHDES is developing for the Great Bay Nitrogen Pollution Sources Study (GBNPSS) are being released. It is important that we use these same data sources in our spatial analysis so that our results can help assess the accuracy of the GBNPSS. We received the finalized 2010 census block population on septic and sewer from the NH DES in July and we met with the New Hampshire Geological Survey (NHGS) in August to formalize a plan to characterize the watersheds of our sample sites for population density on septic and sewer, land use (NOAA 2006), impervious surfaces (UNH 2010 coastal impervious surfaces) and estimate the directly connected impervious area (DCIA; using NHDES/Sutherland 1995 methodology). The NHGS has volunteered to collaborate with us on the spatial analysis since they have recently developed a flow direction grid for the coastal watershed based on 10m DEM data and this will greatly facilitate the watershed assessment GIS process. When the NHDES releases final information on the fertilization rates for managed turf areas and residential lawns and agricultural nitrogen inputs, we will incorporate these layers into our spatial analysis and Great Bay landscape model development.

Previously developed models from the Lamprey and Oyster watersheds that predict nitrogen concentrations based on human population density could not be applied to our extensive sampling sites during this reporting period because additional time is needed to characterize population densities as well as other watershed characteristics for our sampling sites. For the same reason, preliminary Great Bay landscape models could not be developed using the first two rounds of nitrogen data.

As mentioned in section B, a "needs survey" was distributed in the August 2012 Nitrogen Newsbytes newsletter, to solicit input on what sort of data community stakeholders and watershed-focused organizations would like to see depicted in Google Map products. There will be lots of data from this project that we can share, but we want to focus in on the data stakeholders are most interested in.

Progress on **objective** 3 Identify non-point sources of N that reach surface waters and the delivery pathway (e.g. groundwater vs. stormwater) using tracers.

Intensive sites sampled in February 2012 were analyzed for nitrogen concentrations and nitrate isotopes ($d^{15}N\text{-}NO_3$ and $d^{18}O\text{-}NO_3$). Several sites exhibited dissolved inorganic nitrogen (DIN) concentrations $\geq$ 0.80 mg/L and some of these sites may be potential "hot spots" for nitrogen. Driscoll Brook, Hamel Brook, Wednesday Hill Brook and James Farm were sites with elevated DIN and drain areas where people typically rely on private septic systems for waste disposal. Wardley Brook, Moonlight Brook and Gosling Brook were sites with elevated DIN that drained urban areas relying on municipal sewer systems for waste disposal. DIN was 1.86 mg/L in the Burley-Demeritt Creek which drains the UNH Organic Dairy Research Farm during the February sampling. One site (Berry Brook) exhibited surprisingly low DIN for the relatively high population density and impervious cover in the watershed. This site will be further investigated to see if the restoration efforts in this watershed are particularly conducive to nitrogen retention and reduced nitrogen loading.

Nitrate isotope analysis of the February 2012 samples indicated that the source of nitrate in urban, suburban and agricultural streams and shallow groundwater is animal waste, and not from wet deposition, pavement drainage or fertilizer (Figure 1 and 2). Some $d^{15}N\text{-}NO_3$ values were abnormally high (>50) and these samples were from shallow agricultural groundwater (BD5), bulk deposition (West Edge) or from a reference stream in Pawtuckaway State Park. These unusually high values may indicate denitrification, but further research is needed to fully interpret these abnormally high values.

Intensive sites were sampled in August during baseflow conditions for tracer testing and application. These samples collected during baseflow will be used to determine what nitrogen sources are transported to streams in groundwater. A few samples were also collected during storms and those samples as well as the baseflow samples are undergoing laboratory analysis.

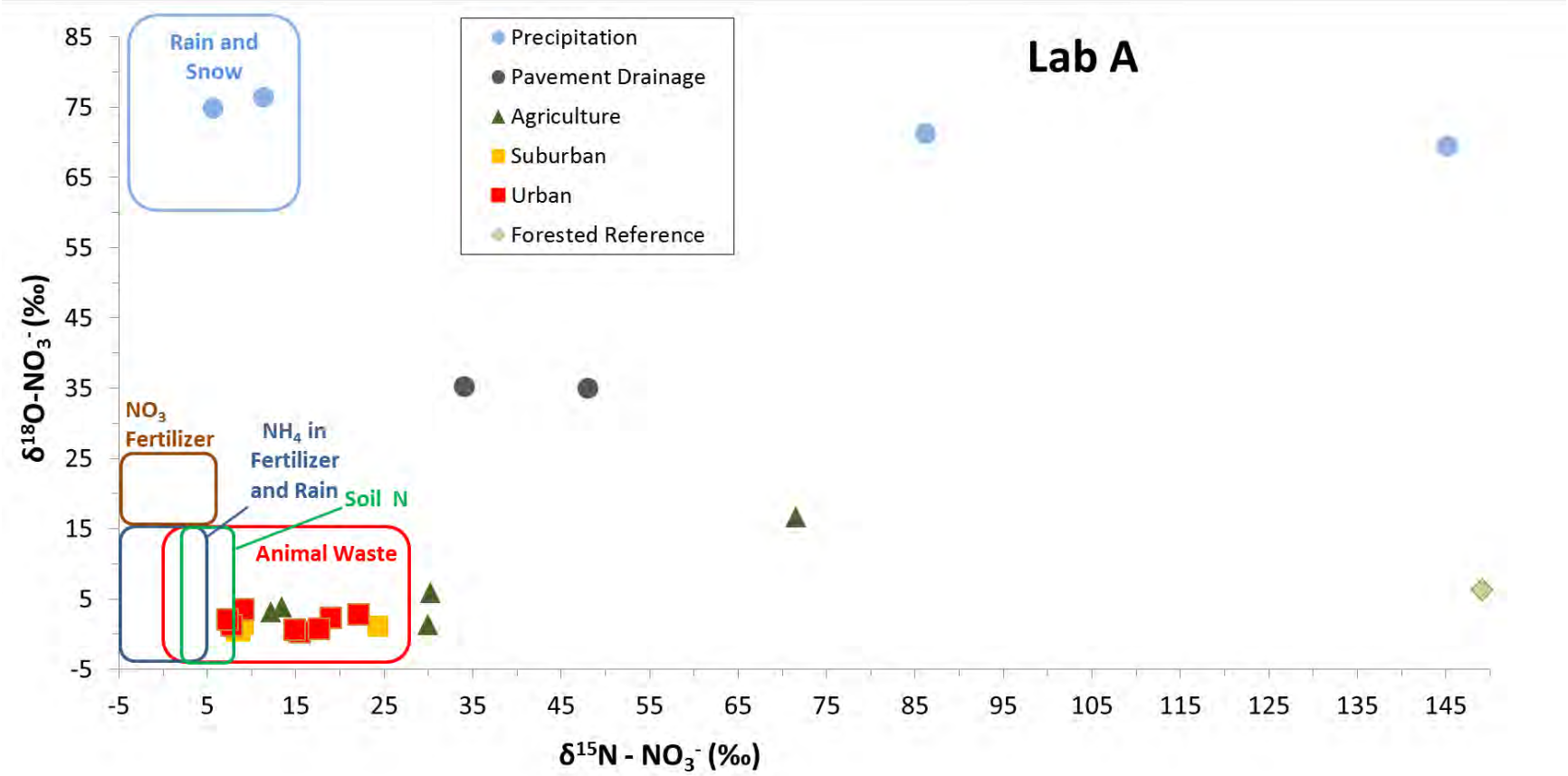


Figure 1. Nitrate isotope data from precipitation, streams and shallow groundwater sampled in February 2012 and analyzed by laboratory "A". Boxes indicating nitrate isotope signatures were identified by Kendall 1998.

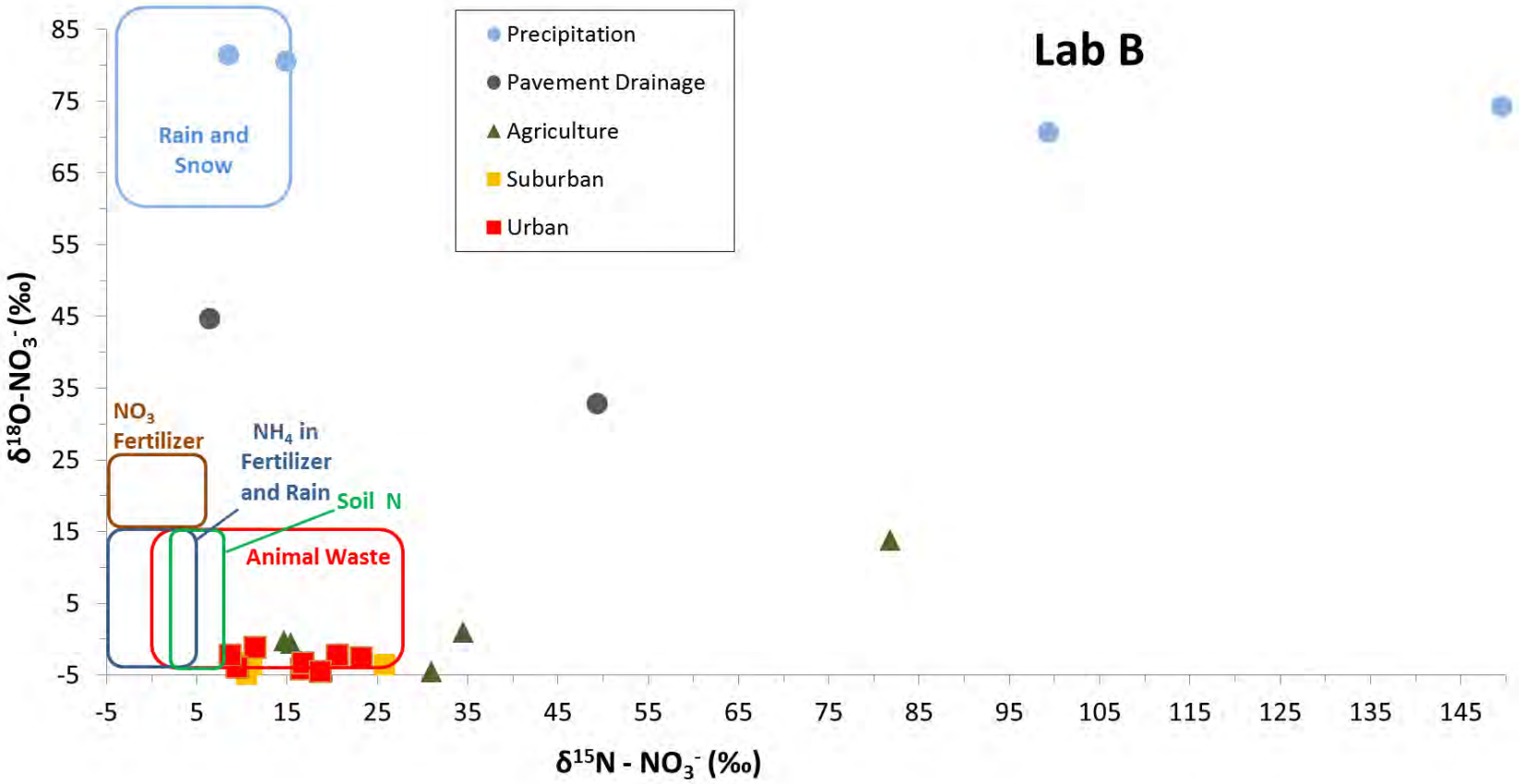


Figure 2. Nitrate isotope data from precipitation, streams and shallow groundwater sampled in February 2012 and analyzed by laboratory "B".

- What data did you collect?

As described previously, we collected feedback from intended users and collected samples and field data from extensive and intensive sites.

- Has your progress in this period brought about any changes to your methods, the integration of intended users, the intended users involved or the project objectives?

We are beginning to ask NSCAB members to become more actively engaged with others in sharing the science resulting from the project. As an example, we are soliciting items for the newsletter from NSCAB members and have encouraged them to actively engage other stakeholders in discussion around the science. We feel that the NSCAB members knowledge of the science has reached a level to enable them to not only engage in informed dialogue, but to work with constituents in their own communities to address nitrogen-related issues.

Significant changes to our objectives were made based on feedback from intended users and these were reported previously.

- Have there been any unanticipated challenges, opportunities, or lessons learned?

Improved spatial datasets that NHDES is developing for the GBNPSS were unexpected at the beginning of the project and present an opportunity for collaboration with NHDES for data sharing. The NHDES spatial datasets are a real asset to this project, but the release of these datasets has delayed our ability to characterize the watersheds of our sample sites. Nitrogen data from this project will help assess the accuracy of the NHDES GBNPSS and this is an important opportunity to build stakeholder trust in the GBNPSS model.

- What are your plans for meeting project objectives for the next six months?

In the next six months we plan to work on objectives 1, 2 and 3 and perform the activities designated under Q1 and Q2 of year 3 (Table 1). These include continued collaboration with stakeholders through approximately quarterly NSCAB meetings and newsletter distribution. Watershed characteristics for extensive sites will be determined and we will analyze and compile N concentration data for extensive and intensive sites. Once watersheds are characterized in collaboration with the NHGS, we will apply models that were previously developed for the Lamprey and Oyster basins to the extensive sites to determine if previous lessons from the Lamprey and Oyster can be extrapolated to the entire Great Bay watershed. We will also then begin to develop preliminary Great Bay landscape models that predict N concentrations based on watershed characteristics. We will use the preliminary models to assess sites for N "hot spots". Intensive tracer testing and application sites will be sampled regularly for N concentrations and during a couple storms for tracer analysis. All available N concentration data will be shared with NHDES as it becomes useful for assessing the accuracy of the GBNPSS.

D. Benefit to NERRS and NOAA: List any project-related products, accomplishments, or discoveries that may be of interest to scientists or managers working on similar issues, your peers in the NERRS, or to NOAA. These may include, but are not limited to, workshops,

trainings, or webinars; expert speakers; new publications; and new partnerships or key findings related to collaboration or applied science.

Members of the project team (Dr. William McDowell, Jody Potter and Michelle Daley) are actively involved in a recently funded NH EPSCoR project: "Interactions among climate, land use, ecosystem services, and society". This NH EPSCoR (Experimental Program to Stimulate Competitive Research) project is funded by the National Science Foundation and contains three themes: terrestrial ecosystem services, aquatic ecosystem services and public and stakeholder understanding and perceptions. The aquatic ecosystem services theme focuses on how climate and land use have influenced water balances and nutrient dynamics in the state's streams and rivers historically, and how future changes are expected to alter these services. Three different aquatic sensor networks (state wide, river network and headwater streams) will deployed to assess how land use, climate change, and climate variability affect water resources at multiple scales. The state wide sensor network will measure basic parameters (conductivity, temperature and stage height) while river network and headwater sites will also measure nitrate, dissolved organic matter, phosphate, turbidity and DO. Data from river network and headwater sites will be available real-time and there is significant focus on the Lamprey and Great Bay watershed which will be useful for this project and the Great Bay NERRS. More information can be found at: http://www.epscor.unh.edu/measuring-impact

E. Describe any activities, products, accomplishments, or obstacles not addressed in other sections of this report that you feel are important for the Science Collaborative to know.